NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS.

TECHNICAL MEMORANDUM. 103

EFFECT OF STRUCTURE IN MIDDLE PART OF LEADING EDGE OF A THICK WING.

Communication from Rijks-Studiedienst voor de Luchtvaart, of Amsterdam.

From Premier Congres International de la Navigation Aerienne, Vol. II, Paris, November, 1921.

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EFFECT OF STRUCTURE IN MIDDLE PART OF LEADING EDGE OF A THICK WING.*

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On the Fokker F III airplane, the pilot's seat is under the front part of the wing. Above this seat the wing is arched out to make room for the pilot's head. A portion of the leading edge is cut away, leaving a space of sufficient width to enable the pilot to look forward along the fuselage. In front of this opening is a wind shield attached to the fuselage. For the sake of improving the view, it would seem desirable to remove a larger portion of the wing. The experiments herein described were made for the purpose of finding whether this modification would be possible, without too great detriment to the aerodynamic properties of the airplane.

Description of Model Used.

Experiments were made with the airplane model No. 5, which is a combination of an existing model of a thick wing, similar in its general characteristics to the wing of the Fokker F III, with a model of the fuselage of the latter airplane made on the same scale as the wing. The landing gear, propeller and tail were omitted, as these parts were not necessary for the experiments. The model was made of mahogany. An opening of the same shape as that on the full-size airplane was made in the leading edge of the wing extending 10 mm beyond either side of the fuselage. Drawings of the model with the principal dimensions, are given in Figs. 1 and 3, while

* From Premier Congrés International de la Navigation Aérienne, Vol. II, pp. 33-38, Paris, November, 1921. (Communication from the "Rijks-Studiedienst voor de Luchtvaart" at Amsterdam.

Fig. 4 is a longitudinal section of the front part.

Several modifications were successively tried, the first, designated model No. 5-A, made use of a brass wind-shield of the same width as the fuselage, with its top edge joined to the top edge of the opening. In model 5-B the openings at the lateral ends of the wind-shield were filled with paraffin, thus restoring the normal wing-section at these points. In all the succeeding models this filling was removed, but the wind-shield was not changed. Successive models were obtained by removing portions of the wing over the pilot's seat extending the whole width of the original opening. The height of the arch is shown in Fig. 4. On the full-sized airplane, the depth of the opening is limited by the position of the front wing-spar. Model 5-E conforms to this limitation.

Method of Testing.

Experiments were conducted in the tunnel of the R.S.L. (Rijks Studiedienst voor de Luchtvaart) with a velocity of 28 m/sec. The horizontal and vertical stresses were measured with an Eiffel balance for angles of attack ranging from -9° to $+6^\circ$. From these measurements, with the aid of the absolute coefficients and the following formulas, the components R_y and R_x were obtained.

$$R_y = L_c \frac{\rho}{g} S V^2$$

$$R_x = D_c \frac{\rho}{g} S V^2$$

R_y, vertical component of drag in kg.;

R_x, horizontal " " " " ";

L_o and D_o, absolute coefficients of lift and drag;

$\frac{\rho}{g}$, mass-density of air;

ρ, weight of air in kg/m.^{3}
g, acceleration of gravity in m/sec^2

S, area of wing in square meters;

V, relative velocity of wind in m/sec.;

Results of Tests.

The values found for the coefficients are represented graphically by polar curves (Fig. 5). In considering these results, we must bear in mind that the model tested does not represent a complete airplane, in that several parts are lacking, which would considerably increase the drag due to parasite resistance. The values found for the coefficients of drag are therefore smaller for the model than they would be for the complete airplane, while the differences between the coefficients obtained for the different models are relatively too great. The following process of reasoning will give us a better appreciation of the significance of these differences.

For a complete airplane model very similar to the one under consideration, there was found a minimum drag coefficient of 0.0285.* It was also found that the parasite resistance of this model was nearly constant for the angles of attack employed in

* Airplane model No. 1-C: Model of Fokker F II airplane in which the front part of the fuselage was modified. A report of these researches has just been published in "Verslagen en verhandelingen van den Rijksstudiedienst voor de Luchtvaart," I, 1921.

normal flight. In the tests under consideration, there was found for model 5-A a minimum D_c of 0.0205. We can therefore obtain approximate values for the drag coefficients of the complete model by assuming an increase of 0.008 of the values found. This is done in the example given further on. The polars of Fig. 5, however, give the values obtained from the experiments.

<u>Influence of wind-shield and of filling openings at ends (models 5-A and 5-B)</u>.- The wind-shield exerts a perceptible influence for all angles of attack. This influence is the smallest when $L_c = 0.200$ and increases for other values of this coefficient. Filling the opening at both ends of the wind-shield makes very little difference.

<u>Models 5-A, 5-C and 5-F</u>.- On increasing the height of the opening 2 mm (No. 5-C), we obtain an increase in the coefficient of drag, for large values of L_c, corresponding to that obtained by removing the wind-shield. The increase is still greater for small values of L_c.

When the dimensions of the opening are made still greater (Nos. 5-D and 5-E), we find quite a large decrease in the coefficient of lift, as well as an increase in the coefficient of drag.

When we give the opening such a shape that we produce a wing section (No. 5-F) for the central part of the lifting surface, we obtain more favorable values than with a vertical edge (No. 5-E). The latter shape is not practicable in a regular airplane, since it gives too unfavorable values.

Numerical Example.

In order to make the importance of the differences more easily understood, we have calculated from the results of the experiments the power required for flight by an airplane with a wing surface of 42 square meters, for different weights and speeds. We made the following assumptions:

1. That the value of the coefficients does not change in passing from the model to the full-sized airplane;

2. That the efficiency remains constant and is 0.7;

3. That we may disregard the increase in drag due to the increase in the velocity of the propeller slip stream;

4. That the parasite resistance not included in the model is estimated at $D_{cp} = 0.008$.

Consequently, we obtained only comparative values. For the calculation, we employed the following formulas:

$$Q = L_c \frac{\rho}{g} S V^2$$

$$75 \mu P = (D_x + D_{cp}) \frac{\rho}{g} S V^2$$

in which

Q is weight of airplane in kg;

S, area of wing in square meters;

V, speed of airplane in meters per second;

L_c, D_c, absolute coefficients of lift and drag for model;

D_{cp}, absolute coefficient of parasite resistance;

ρ/g, mass-density of air;
ρ, weight of air in kg/m^3
g, acceleration of gravity in m/sec^2

μ, efficiency of propeller.

The results are given in the following table:

V in km/h	Q in kg	HP for Model Number.						
		5	5-A	5-B	5-C	5-D	5-E	5-F
100	1200	67	63	63	68	73	100	70
	1600	82	75	78	81	73	136	87
120	1200	108	106	104	112	117	134	115
	1600	112	108	106	113	121	158	117
	2000	125	115	121	125	136	197	132
140	1200	182	176	174	191	194	203	191
	1600	171	168	165	176	185	211	182
	2000	171	168	165	176	188	235	182

The above figures confirm the statements in this report as to the effect of the modifications.

Conclusions.

The results of the tests suggest the following conclusions:

1. The presence of the wind-shield has a favorable influence on the aerodynamic properties, while the filling of the openings at the ends of the wind-shield has little effect;

2. A small upward extension of the opening, without a corresponding extension of the wind-shield (model No. 5-C), exerts a decidedly unfavorable influence, while a larger extension is inadmissible, on account of the resulting excessive increase in the head resistance.

If, therefore, it should be necessary to extend the opening higher, for the sake of obtaining a better view, it must be closed with some transparent material, so as to preserve as nearly as possible the upper camber of the wing.

Translated by the National Advisory Committee for Aeronautics.

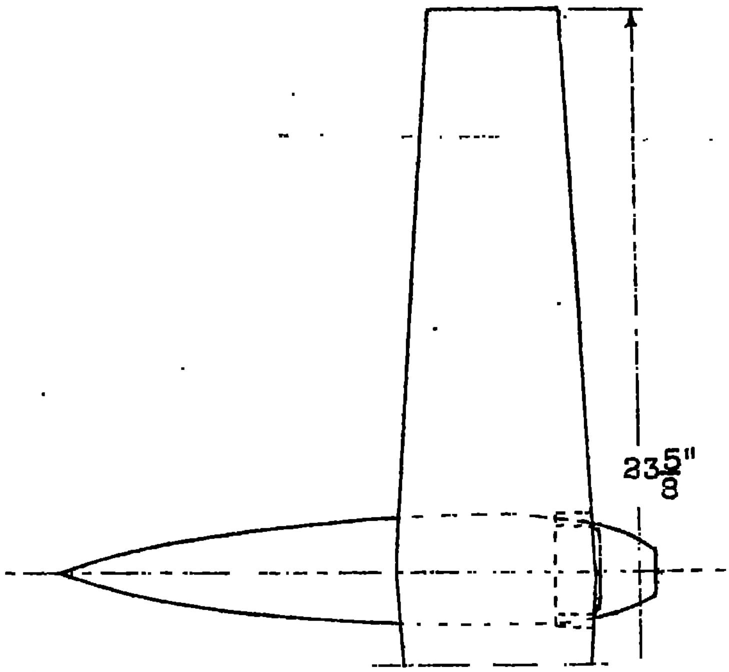

Fig. 3.

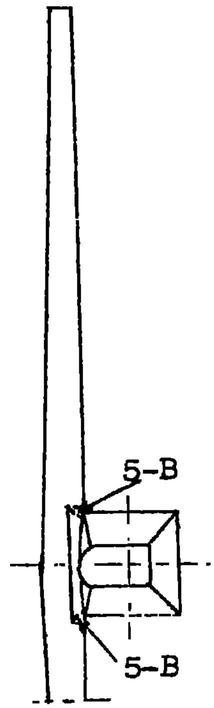

Fig. 2.

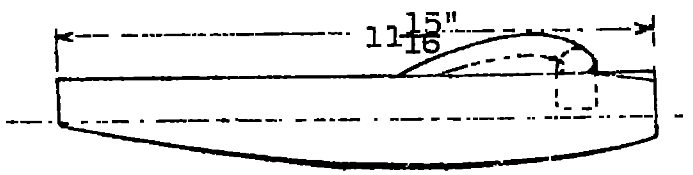

Fig. 1.

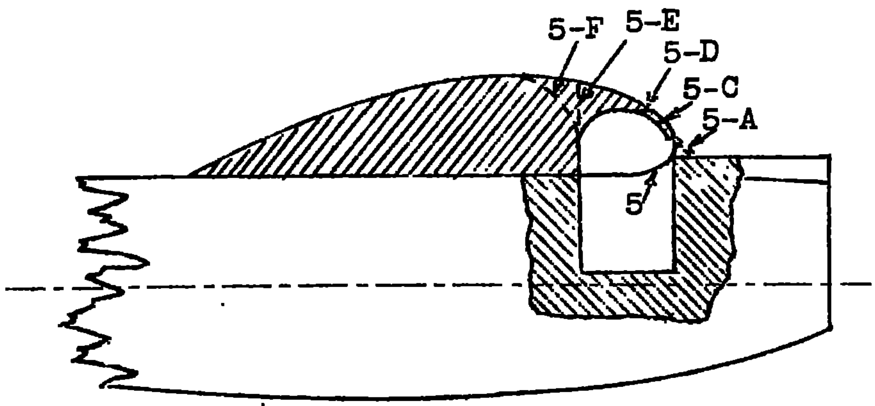

Fig. 4

Figs. 1, 2, 3 and 4. Views of the models showing the different structures.

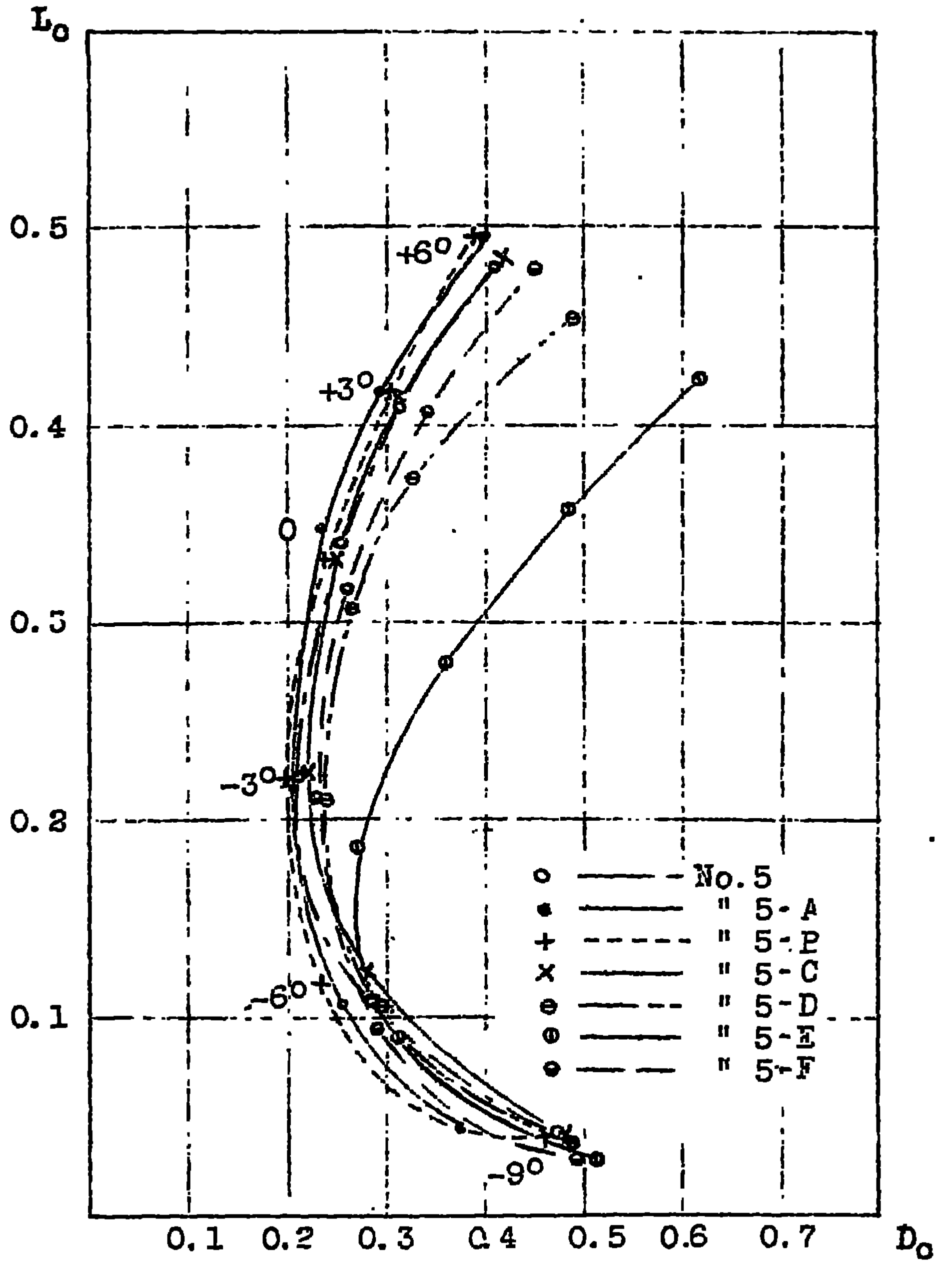

Fig. 5. Characteristics of the different models.